

1. A welding gun for spot welding a workpiece whereupon a weld nugget is
formed that expands and then becomes plastic during the spot welding process, the
welding gun comprising:

- two electrodes, at least one electrode being movable with respect to the other
electrode;
- a power source operative to provide welding power to the electrodes for forming
the weld nugget;
- an electric servo actuator operative to move the at least one movable electrode
toward the other electrode such that the electrodes contact opposite sides of the
workpiece, the actuator operative to apply a predetermined amount of force to the
workpiece;
- a force sensor in communication with at least one of the two electrodes, the force
sensor operative to detect an increase in force on the at least one electrode when the weld
nugget expands and a decrease in force when the weld nugget becomes plastic, the force
sensor further operative to produce a signal indicative of the increase and decrease in
force; and
- a controller in communication with the force sensor and the power source, the
controller operative to receive the signal from the force sensor and to cause the power
source to stop providing welding power to the electrodes after the force sensor detects
the decrease in force due to the weld nugget becoming plastic.

2. The welding gun of claim 1, wherein the controller immediately causes the
power source to stop providing welding power to the electrodes when the force sensor
detects the decrease in force.

3. The welding gun of claim 1, wherein the controller is further in
communication with the servo actuator and operative to control the servo actuator so as to

control movement of the at least one movable electrode in response to receiving the
4 signal from the force sensor.

4. The welding gun of claim 3, wherein the controller is further operative to
2 cause the electrodes to continue contacting the weld nugget when the weld nugget
becomes plastic.

5. The welding gun of claim 3, wherein the controller is further operative to
2 cause the actuator to move the at least one movable electrode toward the other electrode
when the weld nugget becomes plastic.

6. The welding gun of claim 1, wherein the controller is further operative to
2 cause the electric servo actuator to apply increased force to the workpiece when the force
sensor indicates an increase in force due to the weld nugget expansion.

7. The welding gun of claim 1, wherein a contact position is defined as the
2 position of the movable electrode when the electrodes contact the workpiece and the
predetermined amount of force is applied to the workpiece, the actuator being further
4 operative to substantially maintain the contact position when the weld nugget expands.

8. The welding gun of claim 1, wherein a contact position is defined as the
2 position of the movable electrode when the electrodes contact the workpiece and the
predetermined amount of force is applied to the workpiece, the welding gun further
4 comprising a position sensor for sensing the position of the at least one movable
electrode, the position sensor operative to detect a negative change in position when the
6 at least one movable electrode moves away from the other electrode and a positive
change in position when the at least one movable electrode moves toward the other
8 electrode, the position sensor further operative to produce a signal indicative of the
negative or positive change in position, the controller further being in communication

10 with the position sensor and the actuator, the controller further being operative to
substantially maintain the contact position when the weld nugget expands.

2 9. A welding gun for spot welding a workpiece whereupon a weld nugget is
formed that expands and then becomes plastic during the spot welding process, the
welding gun comprising:

4 two electrodes, at least one electrode being movable with respect to the other
electrode;

6 a power source operative to provide welding power to the electrodes for forming
the weld nugget;

8 an electric servo actuator operative to move the at least one movable electrode
toward the other electrode such that the electrodes contact opposite sides of the
10 workpiece, the actuator operative to apply a predetermined amount of force to the
workpiece, a contact position being defined as the position of the movable electrode
12 when the electrodes contact the workpiece and the predetermined amount of force is
applied to the workpiece;

14 a position sensor for sensing the position of the at least one movable electrode, the
position sensor operative to detect a negative change in position when the at least one
16 movable electrode moves away from the other electrode and a positive change in position
when the at least one movable electrode moves toward the other electrode, the position
18 sensor further operative to produce a signal indicative of the negative or positive change
in position; and

20 a controller in communication with the position sensor, the actuator, and the
power source, the controller operative to receive the signal from the position sensor and
22 to cause the actuator to apply an increased amount of force to the workpiece when the
position sensor detects a negative change in position relative to the contact position, the
24 controller further operable to cause the power source to stop providing welding power to
the electrodes when the position sensor detects a positive change in position relative to
26 the contact position.

10. The welding gun of claim 9, wherein the controller immediately causes the
2 power source to stop providing welding power to the electrodes when the position sensor
detects the positive change in position relative to the contact position.

11. The welding gun of claim 9, wherein the controller is further operative to
2 cause the electrodes to continue contacting the weld nugget when the weld nugget
becomes plastic.

12. The welding gun of claim 9, wherein the controller is further operative to
2 cause the actuator to move the at least one movable electrode toward the other electrode
when the weld nugget becomes plastic.

13. A method of spot welding a workpiece whereupon a weld nugget is
2 formed that expands and then becomes plastic during the spot welding process, the
method comprising the steps of:
4 providing a welding gun having two electrodes wherein at least one electrode is
movable with respect to the other electrode;
6 providing a power source in communication with the two electrodes wherein the
power source is operative to provide welding power to the electrodes for forming the
8 weld nugget;
providing an electric servo actuator that is operative to cause the at least one
10 movable electrode to move toward and away from the other electrode;
providing a force sensor in communication with at least one of the two electrodes
12 for detecting the force on the electrode;
providing a controller in communication with the force sensor and the power
14 source;
positioning the workpiece between the electrodes;
16 moving the movable electrode towards the other electrode until the electrodes
contact opposite sides of the workpiece;

18 utilizing the actuator to apply a predetermined amount of force to the workpiece
with the electrodes such that the electrodes are positioned in a contact position;
20 providing welding power to the electrodes such that a weld nugget is formed
between the electrodes and expands and then becomes plastic;
22 sensing the force on the electrode;
 maintaining the electrodes substantially in the contact position while the weld
24 nugget expands; and
 controlling the power source via the controller to stop providing power to the
26 electrodes after the force sensor detects a decrease in force due to the weld nugget
becoming plastic.

14. The method of claim 13, further comprising the step of moving the at least
2 one movable electrode towards the other electrode when the force sensor detects the
decrease in force due to the weld nugget becoming plastic.

15. The method of claim 13, wherein the maintaining step comprises utilizing
2 the actuator to increase the force applied to the workpiece by the electrodes while the
weld nugget expands.

16. A method of spot welding a workpiece whereupon a weld nugget is
2 formed that expands and then becomes plastic during the spot welding process, the
method comprising the steps of:
4 providing a welding gun having two electrodes wherein at least one electrode is
movable with respect to the other electrode;
6 providing a power source in communication with the two electrodes wherein the
power source is operative to provide welding power to the electrodes for forming the
8 weld nugget;
 providing an electric servo actuator that is operative to cause the at least one
10 movable electrode to move toward and away from the other electrode;

providing a position sensor for sensing the position of the at least one movable
12 electrode;
providing a controller in communication with the position sensor and the power
14 source;
positioning the workpiece between the electrodes;
16 moving the movable electrode towards the other electrode until the electrodes
contact opposite sides of the workpiece;
18 utilizing the actuator to apply a predetermined amount of force to the workpiece
with the electrodes such that the electrodes are positioned in a contact position;
20 providing welding power to the electrodes such that a weld nugget is formed
between the electrodes and expands and then becomes plastic;
22 sensing the position of the movable electrode;
maintaining the electrodes substantially in the contact position while the weld
24 nugget expands and allowing the electrodes to move towards each other when the weld
nugget becomes plastic; and
26 controlling the power source via the controller to stop providing power to the
electrodes after the position sensor detects the electrodes move towards one another from
28 the contact position when the weld nugget becomes plastic.

17. The method of claim 16, wherein the maintaining step comprises utilizing
2 the actuator to increase the force applied to the workpiece by the electrodes while the
weld nugget expands.